input terminal AA', both the sets of currents flow simultaneously. The antenna current (I_A) being in the sar direction contributes to radiation while, the transmission line current being in opposite direction does r contribute to radiation (as cancelled out) but, however, contribute to the input impedance. This may now considered as the "antenna impedance" of the folded dipole in parallel with reactance of the series connect shorted transmission lines. Thus the reactance variation of the transmission line section tend to compensa for reactance variations of the antenna. This results in more constant impedance of the antenna, around t resonance (or centre) frequency.

It may however, be noted that the folded antenna is of no use at twice the centre frequency (*i.e.* ev harmonics). Because the short circuited transmission line sections are each $\lambda/2$ long now, which places short circuit across the antenna terminals. This renders antenna useless at this frequency. This fact is importance in connection with television receiving antenna. Further, similarly Yagi-uda antenna is also a broa band antenna as the driven element is almost always a folded dipole.

9.2.3. ***Uses of Folded Dipole.*** In conjunction with parasitic elements folded dipole is used in wid band operation such as television. In this, in the Yagi antenna, the driven element is folded dipole and remainin are reflector and director. Reflector is 5% longer than $\lambda/2$ and directors are by 5% smaller. Grounding i made at point B, the mid-point of unbroken arm.

9.2.4. ***Advantages.*** It has :

(i) High input impedance.

(ii) Wide band in frequency.

(iii) Acts as built in reactance compensation network.

9.3. YAGI-UDA ANTENNA

(AMIETE, May 1980, 1978, 1971, Dec. 1992, 1972)

Yagi-uda or simply Yagi (as generally but less correctly called) antennas or Yagis are the most high gain antennas and are known after the names of Professor S. Uda and H. Yagi. The antenna was invented and described in Japanese by the former some time around 1928 and afterwards it was described by H. Yagi in English. Since the Yagi's description was in English so it was widely read and thus it became customary to refer this array as Yagi antenna, although he gave full credit to professor Uda. Accordingly a more appropriate name the *Yagi-Uda* antenna is adopted following the practice.

It consists of a driven element, a reflector and one or more directors *i.e.* Yagi-uda antenna is an array of a *driven element* (or active element where the power from the T_X is fed or which feeds received power to the R_X) and one or more *parasitic elements* (*i.e.* passive elements which are not connected directly to the transmission line but electrically coupled). The driven elements is a resonant half-wave dipole usually of metallic rod at the frequency of operation. The parasitic elements of continuous metallic rods are arranged parallel to the driven element and at the same line of sight level. They are arranged collinearly and close together as shown in Fig. 9.8 with one reflector and one director. The optical equivalent is also shown.

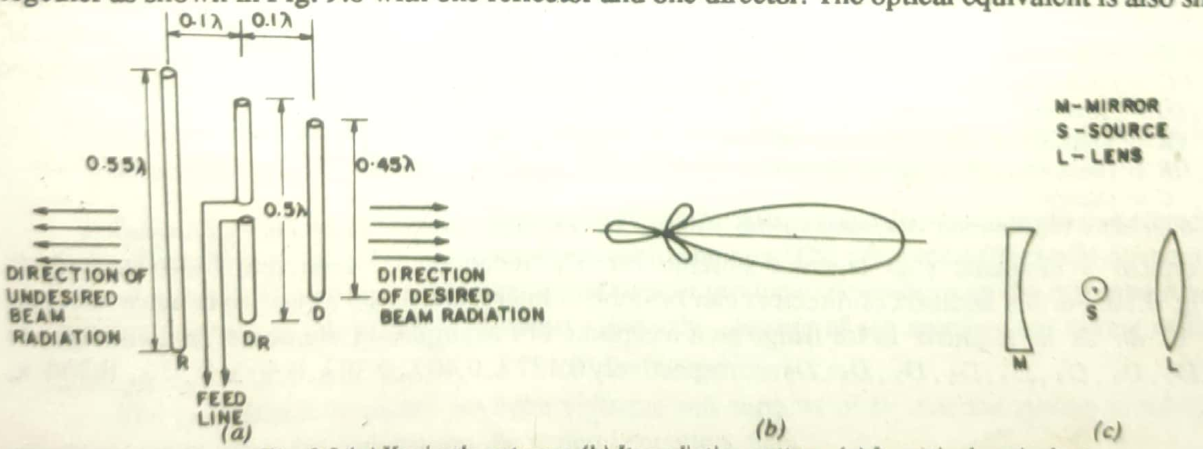


Fig. 9.8 (a) Yagi-uda antenna, (b) Its radiation pattern, (c) Its optical equivalent
R = Reflector (Parasitic element) ; D_R = Driven element ; D = Driector (Parasitic element).

The parasitic elements receive their excitation from the voltages induced in them by the current flow in the driven element. The phase and currents flowing due to the induced voltage depend on the spacing between the elements and upon the reactance of the elements (*i.e.*, length). The reactance may be varied by dimensioning the length of the parasitic element. The spacing between driven and parasitic elements that are usually used, in practice, are of the order of $\lambda/10$ *i.e.* $0.10\,\lambda$ to $0.15\,\lambda$. The parasitic element in front of driven, element is known as *director* and its number may be more than one, whereas the element in back of it is known as *reflector*. Generally both directors and reflectors are used in the same antenna. The reflector is 5% more and director is 5% less than the driven element which is $\lambda/2$ at resonant frequency. In practice, for 3-element array of Yagi antenna the following formulae gives lengths which work satisfactorily.

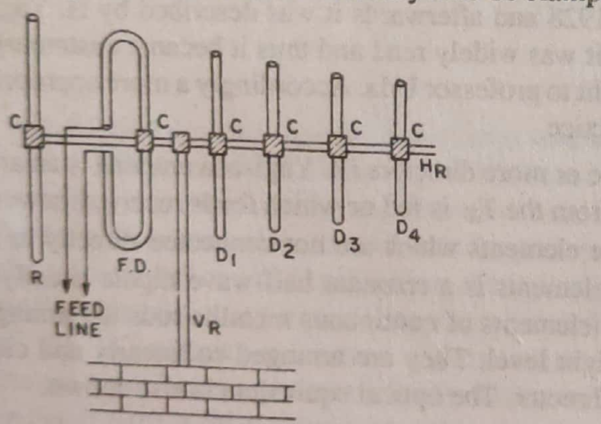
$$\text{Reflector length} = \frac{500}{f\,(\text{MHz})}\ \text{feet} \qquad \dots 9.8\,(a)$$

$$\text{Driven element length} = \frac{475}{f\,(\text{MHz})}\ \text{feet} \qquad \dots 9.8\,(b)$$

$$\text{Director length} = \frac{455}{f\,(\text{MHz})}\ \text{feet} \qquad \dots 9.8\,(c)$$

Eqn. 9.8 provides average length of Yagi antenna determined experimentally for elements of length/diameter ratio of 200 to 400 and spacing from $0.10\,\lambda$ to $0.20\,\lambda$. The parasitic elements can be clamped on a metallic support rod because at the middle of each parasitic element, the voltage is minimum *i.e.* there exists a voltage node. Even driven element may also be clamped if it is shunt feed. The clamping over the support rod makes a rigid mechanical structure.

Further use of parasitic elements in conjunction with driven element causes the dipole impedance to fall well below 73 Ω. It may be as low as 25 Ω and hence it becomes necessary to use either shunt feed or folded dipole so that input impedance could be raised to a suitable value, to match the feed cable. While using folded dipole the continuous rod may also be clamped to the support as shown in Fig. 9.9.



R = Reflector
FD = Folded dipole
$D_1\ D_2\ D_3\ D_4$ = Directors
VR = Vertical rod to support horizontal rods
HR = Horizontal rod to support elements
C = clamps

Fig. 9.9. 6 Elements Yagi antenna with folded dipole.

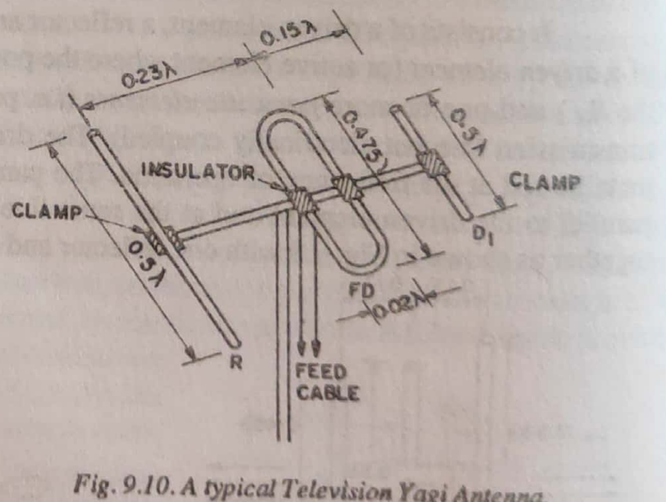


Fig. 9.10. A typical Television Yagi Antenna.

A typical 3 elements yagi antenna suitable for TV reception of moderate field strength is shown in Fig. 9.10. Further addition of directors can be done at intervals of $0.15\,\lambda$ *i.e.* to increase the gain even upto 12 *db* as is required in for fringe area reception. For example, 11 elements Yagi antenna the lengths of $D_2, D_3, D_4, D_5, D_6, D_7, D_8, D_9$ are respectively $0.427\,\lambda$, $0.40\,\lambda$, $0.38\,\lambda$, $0.36\,\lambda$, $0.32\,\lambda$, $0.304\,\lambda$, and $0.29\,\lambda$.